Uncertainties in ΔG Measurement at PHENIX

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I will list what should be considered as uncertainties in ΔG measurement at PHENIX. Mainly I will show the case of prompt photon measurement.

x-independent uncertainties We have uncertainties in beam polarization measurement and luminosity measurement. We expect 10% error at the first stage of the experiment, and 5% at the final stage for the absolute value measurement of the polarization. For the relative value measurement of the polarization, our goal is less than 1%. For luminosity measurement, we expect 10% error at first, and 5% finally about the absolute value measurement. As for relative value measurement, 10^{-4} level precision is required to measure 10^{-3} level asymmetries, because this is used as normalization factor of asymmetry calculation.

x-dependent uncertainties I have reported statistics and subtraction of background mainly from $\pi^0 \to 2\gamma$ at the previous talk. We also need to subtract 10–20% contribution from the annihilation process. It is important to estimate how much asymmetry remains after subtracting backgrounds considering their asymmetries. As for event selection, what should be considered are efficiency corrections for trigger and offline cuts, detector acceptance, etc.

For the prompt photon process, quark polarization is necessary information to evaluate contribution from both the gluon Compton process and the annihilation process. The x region of PHENIX prompt photon measurement is covered by the high precision data of SLAC-E143. Anti-quark polarization is also necessary to evaluate the annihilation process. This information has not been provided yet. We can measure it by ourselves using weak boson measurement.

Theory also includes uncertainties, for instance, in estimation of the annihilation process, higher order corrections, fragmentation function, what Q^2 value should be used, etc.

uncertainties in x estimation There are uncertainties in momentum scale and in photon's p_T vs gluon's x relation. Uncertainty in momentum scale includes momentum resolution and systematic uncertainty by non-linearity of the EM calorimeter. The non-linearity originates from PMT, electronics, shower leakage, etc. Our goal of the non-linearity is 1%, because, for instance, this is enhanced to 6% cross section error at $\sqrt{s}$=500GeV and p_T=20GeV/c. In addition, there is uncertainty due to intrinsic k_T. In PYTHIA simulation, we can switch off initial radiation for k_T. There is difference in low x region between 'k_T on' setting and 'k_T off' setting. This effect for gluon's x estimation is small, but it is interesting topic to investigate.

All transparencies of this talk is accessible on the Web:
`http://www.phenix.bnl.gov/WWW/publish/goto/`

The Asymmetry and Gluon Spin

$A_{LL}(p_T, x_1, x_2)$

$= \frac{1}{rPP}(\frac{N_1/L_1 - N_2/L_2}{N_1/L_1 + N_2/L_2}) - A_{LL}^{background} - A_{TL/TT}$

For Jets:

$= F_{qg}(\hat{a}_{qg}^{LO} + HO(Q^2, \alpha_s))(\frac{\Sigma\Delta q(x,Q^2)}{\Sigma q(x,Q^2)})(\frac{\Delta G(x,Q^2)}{G(x,Q^2)})$

$+(qq \;\; term) + (GG \;\; term)$

For Direct Photon:

$= F_{qg}(\hat{a}_{qg}^{LO} + HO(Q^2, \alpha_s))\frac{g_1}{F_1}(x, Q^2)(\frac{\Delta G(x,Q^2)}{G(x,Q^2)})$

$+(q\overline{q} \;\; term)$

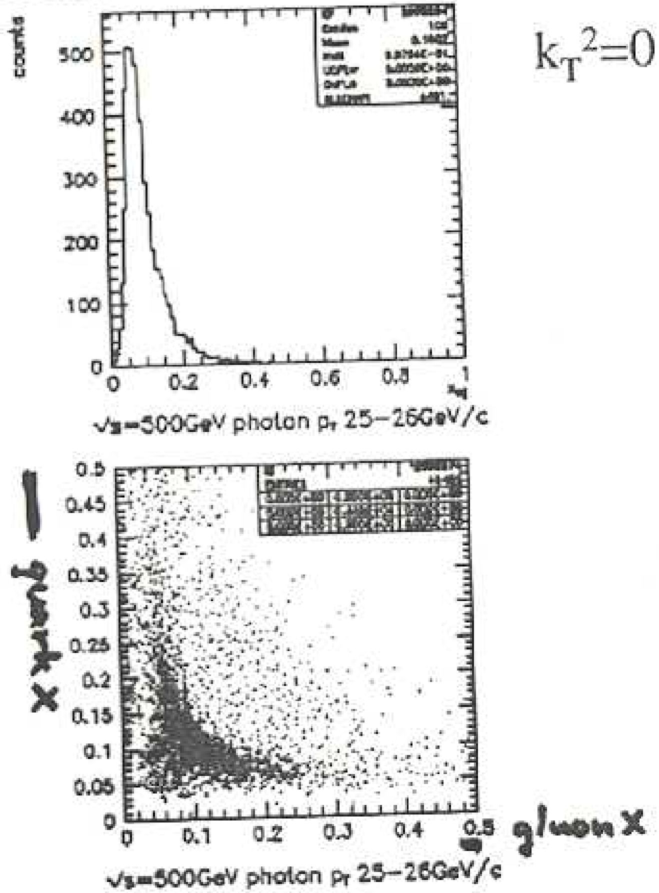
List of Systematic Errors

Error Source	Estimated Size
Error on A_{LL}	
Beam Polarization magnutude	$\Delta A/A = 0.1 \rightarrow 0.05$
Relative Luminosity Measurement	$\Delta A \leq 0.001$
Polarization and Luminosity Correlation	small
Backgounds	
Polarized Backgrounds	
Kinematic Resolution	
Transverse Compornents of Polarization	small
Spin dependent rate (dead time, pile up, etc)	very small
Detector Stability	very small
Detector Asymmetry	very small
Error on ΔG	
Uncertainty on g_1/F_1	$\Delta g/g = 0.05 - 0.1$
Unpolarized quark/gluon PDF	
Polarized quark PDF	
Unforlding PDFs with $x_1, x_2 \rightarrow x_q, x_g$	
QCD Higher Order	
QCD scale factor	
Uncertainty on α_s	
Isolation cut and photon fragmentation function	
QCD k_T smearing	

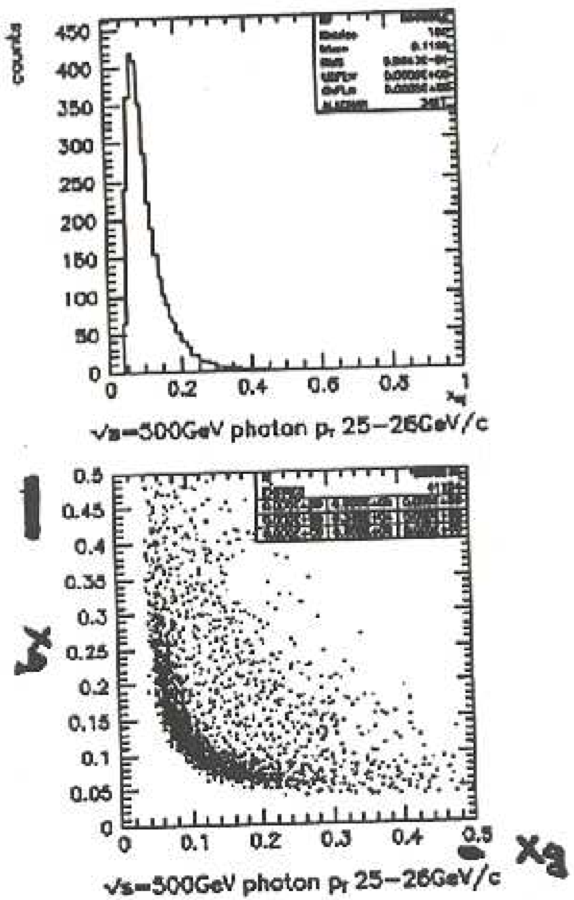
Uncertainties in x Estimation

- p_T vs gluon's x - uncertainty by k_T
  - in PYTHIA initial radiation

$k_T^2=(1-z)Q^2$
z: splitting fraction of initial radiation



$k_T^2=0$



Summary

x-independent uncertainties				
	beam polarization	absolute	10% -> 5%	
		relative	Goal: <1%	
	luminosity	absolute	10% -> 5%	
		relative	10**-4 ?	
x-dependent uncertainties				
	statistics	(for prompt photon)	5% - 30%	(for sqrt(s)=200GeV,
				pT 10 - 30GeV/c, 5GeV/c bin)
	background subtraction	(for prompt photon)	<20% background	(for sqrt(s)=200GeV,
			(* uncertainty of pi0 asym.)	pT 10 - 30GeV/c, 5GeV/c bin)
	hadron & bremsstrahlung		?	
	event selection		<1%	
	theoretical	annihilation process	<20% background	
			(* uncertainty of quark pol.)	
		higher order correction, etc.	?	
		quark polarization	20% - 8%	(for x=0.04 - 0.25 in 15 bins)
uncertainties in x estimation				
	momentum scale		Goal: 1%	
	pT vs x		>50% * slope of asymmetry	
	kT		?	
global analysis			?	